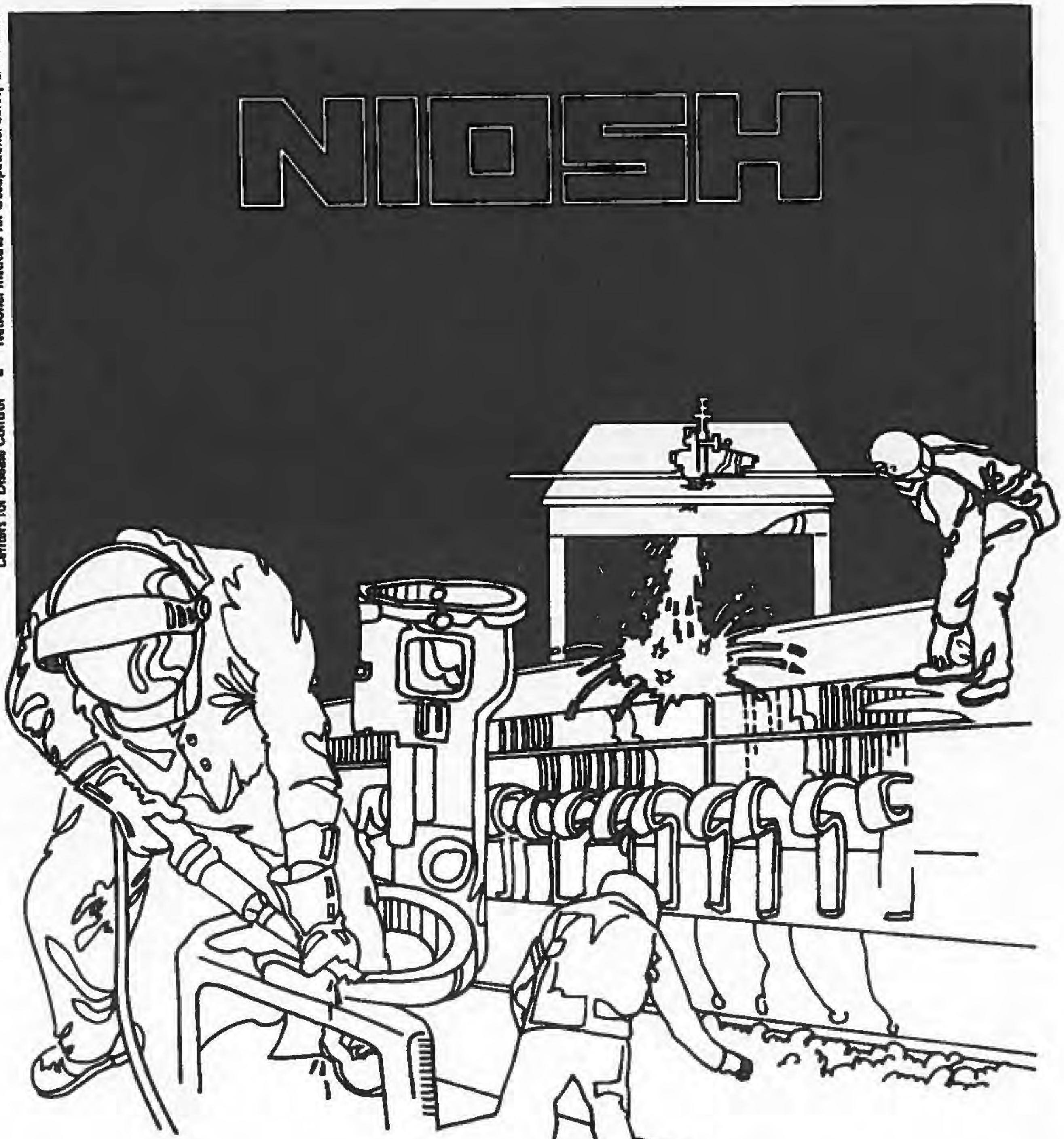
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HHE 80-202-1092
PHILLIPS PETROLEUM COMPANY REFINERY
WOODS CROSS, UTAH

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HE 80-202-1092
APRIL 1982
PHILLIPS PETROLEUM COMPANY REFINERY
WOODS CROSS, UTAH

NIOSH INVESTIGATORS:
Bobby J. Gunter, Ph.D., IH
Theodore W. Thoburn, M.D.

I. SUMMARY

In July 1980 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Oil, Chemical and Atomic Workers International Union in Denver, Colorado, to evaluate exposures to toluene, xylene, acetone, benzene, lead, hydrogen fluoride, aliphatic hydrocarbons, and other toxic substances at the Phillips Petroleum Company Refinery, Woods Cross, Utah. The request also expressed concern about (1) one case of aplastic anemia occurring during the previous year, (2) long-term pulmonary effects from exposure to hydrogen fluoride (HF) gas occurring during a recent fire (May 2, 1980) at the refinery, and (3) a possible excess number of deaths due to leukemia and lymphatic cancers among the 82 workers in the local bargaining unit.

On August 18-21, 1980, NIOSH conducted an environmental evaluation. Twenty-four (24) environmental breathing zone and general room air samples were collected and analyzed for benzene, toluene, and xylene. Five (5) environmental breathing zone air samples were collected and analyzed for lead. One (8.8 mg/M^3) of 24 benzene samples exceeded the evaluation criterion (3.2 mg/M^3). All other air samples for benzene, toluene, lead, and xylene were well within or below the Occupational Safety and Health Administration (OSHA) and NIOSH recommended levels. On August 21-22, 1980, eleven breathing zone and general room air samples were collected for hydrogen fluoride. Only one sample (2.30 mg/M^3) approached the evaluation criterion (2.5 mg/M^3). This sample was collected in a restricted area. Workers entering this area must wear protective clothing, respirators, and other personal protective equipment to prohibit overexposure to hydrogen fluoride. A repeat environmental visit was made on October 17, 1980. Ten breathing zone and general room air samples were collected and analyzed for benzene, toluene, xylene, and acetone. All samples were well within evaluation criteria established for this report.

Workers were studied by individual interview, complete blood count (CBC) and, in selected cases, blood leads and pulmonary function testing. On the initial visit of August 18-22, 1980, five workers out of 33 reported symptoms (headaches or tiredness in particular) suggesting overexposure to organic solvents and/or the more volatile petroleum products. These workers were employed in the laboratory and/or on the gas loading dock. Due to variations in job activity it is very probable that the exposures causing the symptoms were of short duration, allowing the average exposure over the day to be within acceptable limits. Five other workers reported breathing problems, three related to welding, one to dust in the cabinet shop, and one to hydrogen fluoride (HF) exposure at the fire which apparently aggravated a chronic bronchitis. The boiler room was identified as hot with an irritating dust.

On October 15-17, 1980, 79 out of about 95 workers on duty were interviewed and had complete blood counts (CBC). Nineteen of these also had blood lead and erythrocyte protoporphyrin (FEP) determinations. During the fall of 1981 nine of the 13 workers reporting symptoms from HF exposure at the fire had pulmonary function tests.

Follow-up on respiratory complaints due to the fire of May 2, 1980, showed that problems were transient without lasting effects on pulmonary function. This was similar to results found among firemen who were seen immediately after the fire and tested within a week as well as a year later.

Except for some elevated white blood cell counts (WBC) suggesting recent infections, no clinically significant blood abnormalities were found. However, one ex-Yardman had aplastic anemia. History suggested that exposure to fumes emanating from a manhole of a blocked sewer he was helping to clean out was a significant factor in his disease. Although the workers down in the sewer had adequate protective clothing, this worker did not. This non-routine exposure indicates a need to consider non-routine as well as routine exposures in the respirator program.

All blood lead levels were within the normal range, averaging a low 8.9 ug/dl, and all but one of the FEP levels were normal, and that only slightly elevated. There was no correlation between the two values.

Because other studies have already shown an increased risk of leukemia among refinery workers, a large mortality study of this plant except as part of a much larger study does not seem justified in view of the lack of significant abnormal CBC findings.

On the basis of the medical histories and interviews, NIOSH determined that a health hazard existed from exposure to varied petroleum products, solvents and/or gasoline in the laboratory and at the gas loading dock at the Phillips Petroleum Company Refinery at Woods Cross, Utah. Further, the case of aplastic anemia in an ex-worker suggests that past respiratory protection practices in non-routine situations were not adequate. On the basis of medical histories, interviews, and pulmonary funtion tests, it was determined that, except for aggravation of one case of chronic bronchitis, there were no lasting ill effects from HF exposure during the fire of May 2, 1980. Recommendations that may assist in preventing further overexposures are included in this report.

KEYWORDS: SIC 2911 (Petroleum Refining), petroleum refining, toluene, xylene, lead, acetone, hydrogen fluoride, aliphatic hydrocarbons, benzene.

II. INTRODUCTION

In July 1980 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Oil, Chemical and Atomic Workers International Union in Denver, Colorado, to evaluate exposures to toluene, xylene, acetone, benzene, lead, hydrogen fluoride, aliphatic hydrocarbons, and other toxic substances at the Phillips Petroleum Company Refinery, Woods Cross, Utah. The request also expressed concern about (1) one case of aplastic anemia occurring during the previous year, (2) long-term pulmonary effects from exposure to hydrogen fluoride gas occurring during a recent fire (May 2, 1980) at the refinery, and (3) a possible excess number of deaths due to leukemia and lymphatic cancers among the 82 workers in the local bargaining unit.

On August 18-22, 1980, NIOSH performed an environmental and medical investigation. On October 15-17, 1980, a repeat environmental/medical survey was performed. A preliminary report was submitted to management and union in October 1980. A follow-up on pulmonary function was performed by medical staff at the Rocky Mountain Center for Occupational and Environmental Health in the Fall of 1981.

III. BACKGROUND

The refinery produces gasoline and other petroleum products from crude oil. Any antiknock compounds (particularly tetraethyl lead) to be blended in the gasoline are transported to the refinery by tank car and blended in the tank farm. Hydrogen fluoride is used as a catalyst in the refining process.

The refinery runs continuously with most operating personnel working a rotating shift and most maintenance workers working days. The usual progression of jobs in operations is yardman ("bull gang") to tank farm operator ("senior pumper") to laboratory tester to operator to stillman (chief operator). Thus most workers with seniority have served in most operation categories at one time or another.

About two months prior to the initial visit there had been a fire in the refinery (May 2, 1980) with most workers both on and off duty reporting to help fight the fire. Local firemen were also involved. During the fire there was hydrogen fluoride exposure, causing considerable concern, particularly among the firemen--a majority of whom were seen in local emergency rooms for evaluation after the fire.

IV. DESIGN AND METHODS

A. Environmental

The following contaminants were collected on breathing zone and/or general room air samples due to their common occurrence as by-products of refinery operations. Thirty-four (34) samples for benzene, toluene, and xylene, and ten (10) samples for acetone were collected on organic vapor charcoal sampling tubes and analyzed by NIOSH Method P&CAM No. 127. Five (5) lead samples were collected on AA filters and analyzed by NIOSH Analytical Method S-341. Eleven (11) hydrogen fluoride samples were collected on 37 mm filters and analyzed according to NIOSH Method P&CAM No. 212.

B. Medical

On the initial visit 26 current workers on day and evening shifts were interviewed. Additionally, reviews were made of the OSHA log for the past few years, the recent study of the plant by Utah OSHA, and the study of pulmonary effects on firefighters being conducted by the Rocky Mountain Center for Occupational and Environmental Health, University of Utah.

Private physicians were contacted when pertinent, and seven additional workers and ex-workers identified by the union or in the interviews were contacted and interviewed by phone.

Based on the initial information the repeat medical visit included a medical questionnaire (seeking exposure information, medications, smoking habits, and activities at the fire) and a complete blood count (CBC) done at a local laboratory. Selected workers with a history suggesting recent exposure to lead also had blood lead and free erythocyte protoporphyrin (FEP) levels determined. In all, 79 workers out of about 95 workers on duty were included in this follow-up study.

Job breakdowns of workers involved are shown in Table 1. Table 2 characterizes the follow-up study group by job, age, years with company, years in position, sex, and smoking habits.

Follow-up pulmonary function tests were performed by the Rocky Mountain Center for Occupational and Environmental Health, the University of Utah, Salt Lake City, Utah, on some of the firemen, and many of the workers identified as being at the fire and having at least transient symptoms of HF exposure. Eight (8) of the 14 firemen originally studied May 7, 1980, were also studied on August 19, 1981. Nine (9) of 13 Phillips workers who reported respiratory or irritative symptoms were studied in the fall of 1981.

Pulmonary function tests were done utilizing an Ohio 822 rolling seal siprometer. Predicted values were calculated to correct for height, age, sex, and race using the formulas developed by Knudson, et al.[1]

V. EVALUATION CRITERIA

A. Environmental

Three sources of criteria used to assess the workroom concentrations of the chemicals were (1) recommended Threshold Limit Values (TLVs) and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1981, (2) the NIOSH criteria for a recommended standards, and (3) the Occupational Safety and Health Administration (OSHA) standards (29 CFR 1910.1000), July 1980.

	Permissible Exposure Limits 8-Hour Time-Weighted Exposure Basis		
	NIOSH	OSHA	ACGIH/TLV
Benzene....................	3.2 mg/M^3 C	30 mg/M^3	30 mg/M^3
Acetone....................	2400mg/M^3	2400 mg/M^3	1780 mg/M^3*
Hydrogen fluoride.........	2.5 mg/M^3	2.5 mg/M^3	2.5 mg/M^3
Lead......................	0.05 mg/M^3	0.05 mg/M^3	0.15 mg/M^3
Toluene...................	375 mg/M^3	750 mg/M^3	375 mg/M^3
Xylene....................	435 mg/M^3	435 mg/M^3	435 mg/M^3

mg/M^3 = milligrams of substance per cubic meter of air.
* = Intended Changes 1981
C = Ceiling concentration - 30 minute

Occupational health standards are established at levels designed to protect individuals occupationally exposed to toxic substances on an 8-hour per day, 40-hour per week basis over a normal working lifetime.

B. Toxicological

Acetone[2] -- Acetone may be ingested and inhaled. It is a mucous membrane irritant and a depressant to the central nervous system (CNS). Overexposures may produce eczema, conjunctivitis, and corneal erosion. Headaches, dizziness, mental confusion, weakness, and narcosis are the most frequent findings when a worker is exposed to levels exceeding 1780 mg/M^3.

Aliphatic Hydrocarbons[3,4] -- Aliphatic hydrocarbons are derived from petroleum by the cracking, distillation, and fractionation of crude oil. They are compounds composed of carbon chains with attached hydrogen atoms. The chains may be branched and some adjacent carbons may not have a full quota of hydrogen atoms (called unsaturation). As a rule, the longer the carbon chain, the less volatile the compound. Branching and unsaturation increase the volatility of the compound. As usually found in the workplace, the usual fractions of aliphatic hydrocarbons are mixtures of different length carbon chains with different degrees of branching but all having a similar boiling point within a fairly narrow range.

Methane (1 carbon) and ethane (2 carbons, saturated) are both gases whose only danger to health, other than the danger of explosion, is asphyxiation if too much oxygen is displaced. Other short-chained gaseous hydrocarbons are central nervous system (CNS) depressants, as well as possible asphyxiants. As a general rule, up to a chain length of 7 carbons (heptane), the fewer carbons, the less toxic, but more rapid the depressant effect. With more than 7 carbons the toxic effects progressively decrease and the time frame continues to increase. Toxic effects are primarily CNS depression and irritation of the respiratory tract. Low level CNS depression may be felt as a headache. The liquid hydrocarbons may irritate the skin and can cause dermatitis by defatting the skin on repeated and/or prolonged exposure. All of the liquid hydrocarbons are extremely irritating to the lungs if aspirated; so if swallowed, a person should not be made to vomit. n-Hexane (6 carbons, unbranched) can cause a peripheral neuritis on repeated exposure.

Gasoline is a mixture of hydrocarbons (with or without anti-knock or other additives) primarily in the 5 to 10 carbon range, mostly aliphatic, but often containing some aromatics (benzene, toluene, xylene). Liquified petroleum gas (LPG) is a mixture of propane (3 carbons) and butane (4 carbons). Petroleum naphtha is aliphatic hydrocarbons in the 6 to 8 carbon range. Kerosene is aliphatic hydrocarbons in the 10 to 15 carbon range. Aliphatic hydrocarbons with 17 or more carbons are solids at room temperature and if purified, pose a minimal health hazard.

Benzene[5] -- Benzene is highly toxic either by inhalation or skin absorption. Benzene is metabolized in the body to a phenolic compound which may alter the DNA molecule in bone marrow with injury to blood forming tissue. It produces liver necrosis and is also a central nervous system (CNS) depressant. Benzene is a carcinogen producing leukemia. Benzene is known to cause aplastic anemia, macrocytosis, leucopenia, thrombocytopenia, and hemolysis.

Hydrogen Fluoride[6,7] -- The current OSHA standard for hydrogen fluoride (HF) is 3 ppm or 2.5 mg/M^3. NIOSH recommends 2.5 mg/M^3 and a ceiling level of 5 mg/M^3 averaged over a 15 minute period.

Hydrogen fluoride can affect the body if it is inhaled, ingested or absorbed through the skin.

1. Short-term Exposure -- HF liquid or vapor causes severe irritation and deep-seated burns of the eye and eyelids if it comes in contact with the eyes. If HF is not removed from the eye immediately, permanent visual defects or blindness may result. HF is a severe irritant to the nose, throat, and lungs. Breathing difficulties may not occur until some hours after exposures has ceased. Death may occur from breathing this chemical. If swallowed, HF will immediately cause severe damage to the throat and stomach.

   A physician should be contacted if anyone develops signs and symptoms of overexposure.

2. Long-term Exposure -- Chronic low level exposures may cause irritation and congestion of nose, throat, and bronchial tubes. Although unlikely from HF exposure due to its acute effects, long-term exposure to excessive fluoride levels can cause mottling of the teeth, increased bone density, and calcification of tendons and ligments (particularly of the back).

Recommended medical surveillance should include a complete history and medical examination. The purpose is to detect any pre-existing condition that might place the exposed employee at risk. Examinations should include the eyes, respiratory tract, central nervous system, skeletal system, and kidneys. The following examinations and tests are recommended on a regular basis if excessive HF exposure is likely: pelvic roentgenogram, eye examination, 14" x 17" chest roentgenogram, pulmonary function FVC and FEV (one second), and skin disease.

Lead[8,9] -- Inhalation (breathing) of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs (bone marrow). These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/deciliter* whole blood are considered to be normal levels which may result from daily environmental exposure. However, fetal damage in pregnant women may occur at blood lead levels as low as 30 ug/deciliter. Lead levels between 40-60 ug/deciliter in lead-exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60-100 ug/deciliter represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/deciliter are considered dangerous and often require hospitalization and medical treatment.

The Occupational Safety and Health Administration (OSHA) standard for lead in air is 50 ug/M^3 calculated as an 8-hour time-weighted average for daily exposure. The standard also dictates that workers with blood lead levels greater than 60 ug/100 g whole blood* must be immediately removed from further lead exposure if confirmed by a follow-up test and, starting from March 1, 1983, workers with average lead levels of 50 ug/100g or greater must also be removed. Removal is also possible on medical grounds. Removed workers have protection for wage, benefits, and seniority for up to 18 months until they can return to lead exposure areas.

Most lead exposure at the refinery will be to the anti-knock additives for regular gasoline (tetraethyl and tetramethyl lead). Unlike inorganic lead, these organic lead compounds are readily absorbed through the skin as well as the lungs. Once diluted in gasoline this is not much of a problem.

Brief, high exposure or lower, more prolonged exposure to organic lead compounds cause central nervous system intoxication which may last a few days to weeks, and may cause death early in the intoxication. Mild intoxication can cause tiredness, sleeplessness, lurid dreams, anxiety, and hallucinations. There may also be tremors, disorientation, hyperactivity and, in more severe cases, convulsions, coma, and death. There may be relatively quiet periods between episodes of symptoms.

Besides the symptoms, the best test for possible organic lead intoxication is the level of lead in the urine, as organic lead is rapidly excreted, rarely leading to an elevated blood lead level.

---

* 1 ug/deciliter whole blood is roughly equivalent to 1 ug/100 g whole blood.

Toluene[10] -- Toluene is a clear, colorless, non-corrosive liquid with a sweet, pungent, benzene-like odor. Approximately 70% of all toluene that is produced is converted into benzene. Extreme caution when using toluene should be taken since it is often contaminated with benzene. It is dangerously absorbed both by inhalation and skin absorption. Toluene is an irritant and a central nervous system depressant. Some of the common symptoms include defatting dermatitis, bronchitis, pneumonitis, nausea, vomiting, headaches, dizziness, irritability, and inebriation.

Xylene[11] -- Xylene overexposures may cause headache, nausea, gastrointestinal disturbance, and dizziness. Eye, nose, throat, and skin irritation are also common complaints when workers are exposed to xylene. Workers exposed to xylene should have laboratory test for complete blood count, a routine urinalysis, and liver function test.

C. Medical

1. Complete Blood Counts (CBC)

The components of a CBC are a Red Blood (cell) count (RBC), Hemoglobin determination (Hgb), Hematocrit (Hct), White Blood (cell) Count (WBC), and examination of a stained blood smear for size and shape of red cells, abundance of platelets and a count of the numbers of various varieties of white cells (differential count). Abnormally large numbers of any type of cell suggest a leukemia or other abnormality of bone marrow function. Abnormally decreased numbers of cells suggest toxicity to the bone marrow. Less drastic specific changes are used to help diagnose specific medical problems. Insufficient iron in the diet or exposure to some toxins affecting hemoglobin synthesis, such as lead, can cause anemia which will tend to decrease the number of red cells, the hemoglobin and the hematocrit. Infections tend to increase the white blood count to varying degress and make shifts in the differential count.

Decreased numbers of red cells and/or decreased amount of hemoglobin, besides making the person look pale, decrease the blood's ability to carry oxygen leading to easy tiring. Decreased numbers of white cells decrease the body's ability to fight infection. (Also the case where there are increased numbers of abnormal white cells in leukemia.) Decreased numbers of platelets reduce the ability of the blood to clot leading to bleeding tendencies and easy bruising. Slight abnormalities in red cell size or shape are not clinically significant and probably represent different degrees of diligence on the part of the laboratory doing the test. More marked abnormalities can help diagnose deficiencies, toxicities, or maligancies. Also, when present, the blood smear is useful in diagnosing blood parasites, such as malaria.

2. Pulmonary Function Tests

The pulmonary function tests included measurements of forced vital capacity (FVC), one-second expiratory volume (FEV_1) and calculation of the ratio of FEV_1/FVC. FVC measures the total amount of air one can force out of his lungs after breathing in as deeply as possible. FEV_1 measures the amount of air one can breathe out in the first second. The FVC can be impaired by restrictive lung disease, such as pulmonary fibrosis. FEV_1 can be impaired by cigarette-related lung damage or some other conditions causing obstruction to air flow. Any condition that impairs FVC usually impairs FEV_1, but the reverse is not true. Conditions that impair FEV_1 do not necessarily impair FVC. The FEV_1/FVC ratio is also used to help evaluate obstructive lung disease.

In interpreting the results, the best test results are used. They are compared to "predicted values" which take into account age, height, sex, and race. Pulmonary function is considered "normal" if the best FEV_1 and the best FVC are each 80 percent or more of their respective predicted values and the FEV_1/FVC ratio using the best values is 70 percent or more.

VI. RESULTS AND DISCUSSION

A. Environmental

Twenty-four (24) environmental breathing zone and general room air samples were collected on August 18-20, 1980, and analyzed for benzene, toluene, and xylene (Table 3). Five environmental breathing zone air samples were collected on August 18-21, 1980, and analyzed for lead (Table 4). One (8.8 mg/M^3) of 24 benzene samples exceeded the evaluation criterion (3.2 mg/M^3). All other air samples for benzene, toluene, xylene, and lead were well within the Occupational Safety and Health Administration (OSHA) and NIOSH recommended levels. On August 21-22, 1980, eleven breathing zone and general room air samples were collected and analyzed for hydrogen fluoride (Table 5). Only one (2.30 mg/M^3) sample approached the evaluation criterion (2.5 mg/M^3). This sample was collected in a restricted area. Workers entering this area must wear protective clothing, respirators, and other personal protective equipment to prohibit overexposure to hydrogen fluoride. A repeat environmental visit was made on October 17, 1980. Breathing zone and general room air samples were collected and analyzed for benzene, toluene, xylene, and acetone (Table 6). All samples were well within evaluation criteria.

Operations at the time of this survey were very typical of a refinery operation of this type. Repeat visits would probably indicate similar exposures.

B. Medical

1. Initial Visit

Of 33 current workers interviewed in person or by phone, 16 had no current problems (work related or not): five had breathing problems (current or in past)--three relating to welding, one to dust in the cabinet shop (with a bronchopneumonia), and one in an ex-heavy smoker who probably has a chronic bronchitis which was probably aggravated by hydrogen fluoride exposure at the fire; six had symptoms suggestive of exposure to organic solvents and the more volatile petroleum products (headaches or tiredness in particular)--three related this to work in the laboratory, one to work on the gas loading dock, and one to both places. The last worker was an operator who did not particularize the complaint. One worker complained of the heat in the boiler house and another mentioned that the dust there caused a raw throat.

Remaining complaints showed no pattern nor any clear relationship to work except for a couple of accidents.

Nineteen of the workers related being at the fire, ten manning hoses and nine doing other things, primarily shutting down units. Three workers on the hoses reported more HF than usual causing irritation and cough. Two were better by the next day. Five workers on the hoses and five not on the hoses reported HF exposure less than or equal to normal. Only two workers actually had complaints they felt were significant: one had some irritation, clearing in a couple of hours; the other noted that his glasses became etched. Two workers on the hoses and four not on hoses reported no HF exposure during the fire. Two of these reported some breathing problems from the fumes, clearing shortly after they were out of the fire. Breathing problem are discussed further under the follow-up visit.

2. Follow-up Visit

a. Blood Work and Aplastic Anemia

One ex-Yardman has been diagnosed by his private physician after extensive work-up as having aplastic anemia, in this case characterized by a decreased production of red cells, white cells and platelets, rather than a complete absence of production. The most likely cause of this blood disorder is exposure to something which is toxic to the bone marrow, although the specific toxic substance usually has to be identified by history if it can be identified at all. Besides possible exposures to a variety of petroleum products at the Phillips refinery, this worker had used pesticides in his home containing naphthyl derivatives and had worked as an asphalt spreader immediately prior to his work at Phillips.

Because red blood cells normally last about four months after they are produced in the bone marrow, the effects of a toxin reducing red cell production would not be felt for a month or two after exposure. In white cell production problems would show up sooner. In this case the diagnosis was first suspected based on laboratory work when the worker was sicker with a minor illness than he should have been and had been feeling more tired than might be expected. Similar blood studies one month earlier had been within normal limits. Most of this worker's potential exposures to petroleum products were either too close or too far from the time of diagnosis and were accompanied by adequate protective equipment and/or environmental testing or cleansing. However, about two months prior to his diagnosis, this worker was involved in cleaning out a blocked sewer from the south end of Unit 11, a job lasting a week or so. The man entering the sewer used an air line respirator; however, this worker was stationed right at the manhole without respiratory protection. Reportedly the fumes were quiet noticeable. Although this particular exposure may not have been the sole cause of this worker's problem, its history and timing suggest it was a significant factor.

Because the last plant-wide survey of blood for possible ill effects of benzene was conducted in 1977, on the follow-up visit Complete Blood Counts (CBC's) were done on the 79 workers who participated. Results are tabulated in Tables 7, 8, and 9. No cases of anemia or leukemia were found. One worker showed a decreased white blood count due to a decrease number of lymphocytes, but a repeat blood test was normal.

Several workers showed elevations in their white counts consistent with current or recent infections.

A few statistically significant differences were observed. As shown in Table 7, smokers had a higher average White Blood Count (WBC), Neutrophil Count and Lymphocyte Count than did non-smokers. This phenomenon has been previously reported by Corre, et al.[12] They also had higher Hematocrits (Hct) with slightly larger red cells (Mean Corpuscular Volume - MCV) which are slightly poorer in hemoglobin (Mean Corpuscular Hemoglobin Concentration - MCHC). As expected, the women showed lower Red Blood Counts (RBC), Hemoglobins (Hgb) and Hematocrits (Hct) than did the men.

The relations between WBC, Neutrophils, Free Erythrocyte Protoporphyrin (FEP) and the presence of slight abnormalities in the size and/or shape of red cells will be discussed along with the lead testing.

In summation, other than one ex-Yardman, no cases suggesting aplastic anemia were found. This one case indicates the need to consider possibilities of unconventional exposures when workers are called on to do non-routine jobs. Usual practice requires the "buddy" of a man entering a hazardous atmosphere to also be equipped with suitable protective equipment in case entry for rescue becomes necessary. In this case it appears this would have also been desirable for protection of the "buddy" to avoid ill effects from vapors emitting from a very restricted opening.

b. Lead Exposures, "Solvent" Exposures, and Abnormalities of Red Cell Shape or Size

Twenty-one of the 79 workers studied showed some slight abnormalities of size and/or shape of their red blood cells (RBC). All workers with RBC abnormalities were men; however, because the workers studied were primarily men the difference between sexes is not statitistically significant. Table 8 explores statistically significant associations between exposure by history and the presence of RBC abnormalities. As exposure to leaded gasoline can be classed as both a solvent exposure and as a lead exposure, there is considerable overlap of the two categories of solvent exposure and lead exposure. Table 9 further explores the relationship between average WBC, Neutrophil Count, and FEP and the presence of abnormalities of RBC's among male workers. A category of "solvent" exposure did not seem to relate to these three parameters. Men with the slight abnormalities of RBC's had statistically higher FEP's than men without such abnormalities. The same was true of men with a history of tetraethyl lead (TEL), gasoline, or other lead exposure when compared to men not on medication and not having such exposures, although the mean FEP level was not as great. The relationship between FEP and abnormalities of the RPC's was also found when the work force was divided into current smokers and non-smokers (including ex-smokers), although only for non-smokers were the numbers and the difference large enough to reach statistical significance.

All blood leads were within the normal range (less than 40 ug/dl), averaging in the low normal range (8.9 ug/dl). All but one FEP were within the normal range (less than 50 ug/dl). That one was not overly high (63 ug/dl) and was not related to an elevated blood lead. There was no correlation between FEP and Blood Lead levels.

In summary, there appears to be a slight relationship between minimal abnormalities of red cell size and/or shape and exposure to lead, leaded gasoline, and/or solvents. Also, workers with these red cell abnormalities showed a higher average FEP. No clinical significance can be attached to these findings.

c. Respiratory Complaints and Exposures to HF at the Fire on May 2, 1980

(1) Firefighters

Firefighters from Bountiful City and North Salt Lake Departments were among those responding to the fire.

A number of firemen were exposed to HF while not using respiratory protection. Twenty-three (23) were taken to the emergency room at Lakeview Hospital, 16 being checked and released and seven hospitalized for observation. One of these latter was in the hospital for several days with pneumonia.

Five days after the fire (May 7, 1980) the Rocky Mountain Center for Occupational and Environmental Health performed pulmonary function tests on 14 of the firemen at the Bountiful City fire station (see Table 10). All but two were within the normal range. One who had just been released from the hospital where he had been treated for pneumonia, showed borderline abnormalities suggesting restrictive disease. The other, whose functions were closer to normal, had shown a mild interstital infiltrate on chest x-ray and possible chest rales following the fire and so had been admitted overnight.

On August 19, 1981, eight of the initial 14 firemen were retested by the Rocky Mountain Center for Occupational and Environmetal Health. All but one were in the normal range. One fireman with borderline findings was not available for retest. The other showed a slight increase in FVC. Overall FVC increased by 0.6 percent-of-predicted points and FEV_1 dropped by 1.8. FEV_1/FVC dropped by 2.3 points. These changes are neither statistically nor medicaly significant. Excluding those individuals with light exposure from the analysis also failed to show a trend.

(2) Phillips Workers

As the preliminary survey suggested that there were some respiratory complaints related to the fire and to HF in particular, this was further explored in the follow-up questionnaires. Results are summarized in Table 11. In general, those exposed to HF were the ones having respiratory or irritative symptoms and those with greater than normal exposure were more likely to have symptoms. Those working hoses were more likely to have had an HF exposure, but exposure or the presence of symptoms did not relate to the time on the hose.

In the fall of 1981 the Rocky Mountain Center for Occupational and Enviromental Health tested pulmonary functions on nine of the 13 workers exposed to HF during the fire and reporting at least transient symptoms as a result. Results are summarized along with the firemen in Table 10. All were within normal limits. Although the smokers and ex-smokers averaged lower FVC's and FEV_1's than non-smokers, this did not quite reach statistical significance. Any possible relationship between pulmonary functions and HF exposure was even less marked than the relationship with smoking and was confounded by smoking history.

d. Leukemia Cases

The International Union expressed some concern about the number of leukemias or cancers over a number of years. Out of 82 workers in the bargaining unit, they identified one leukemia case in each of 1962, 1966, 1968, and 1970. In addition they identified the case of aplastic anemia mentioned in this report. Two other names were also mentioned without definite diagnosis. One was seen and was apparently in good health.

To explore the question of increased mortality from leukemias would require a large mortality study and require considerable investigator time as the company records are located in the corporate offices in Bartlesville, Oklahoma, and death certificates would have to be obtained from the various states after tracing the vital status of all workers and ex-workers from a number of years back. The job rotation observed at this plant, coupled with the small size of the work force, make it very unlikely that any particular process or job at this plant could be identified as the cause of any increase in mortality that might be found. Thus it is highly unlikely that we could relate the four cases of leukemia identified by the union and any others that might be found to anything more specific than working in an oil refinery with possible exposure from time to time to substances already known to cause leukemia.

In a study of three oil refineries in Texas[13] conducted cooperatively by the National Cancer Institute, NIOSH, and the Oil, Chemical and Atomic Workers International Union, 2,509 active and retired union members were traced. Proportionate mortality ratios suggested increased risk of death due to leukemia, multiple myeloma and other lymphomas, as well as to stomach cancer and brain tumor. It would seem reasonable to assume that the Woods Cross refinery would carry risks similar to the Texas refineries, allowing perhaps for differences in drinking or smoking habits. If further mortality studies on oil refineries are to be undertaken, it would seem reasonable to include Woods Cross in the study, but not reasonable to do a study of this refinery alone.

VII. CONCLUSIONS

A. Environmental

Environmental results did not indicate a pattern of overexposure to workers in any of the departments at the Woods Cross refinery at the time of the surveys. Careful examination of Tables 4 and 5 illustrate that workers in the laboratory such as the testers are receiving the highest exposures.

B. Medical

Based on individual interviews on the initial visit, workers in the laboratory and on the gas loading dock have at least transient overexposure to varied petroleum products, solvents and/or gasoline. Predominant complaints are headaches and tiredness. Also there is the possibility of respiratory problems among the welders.

Follow-up on workers with respiratory complaints due to HF exposure at the fire on May 2, 1980, including pulmonary function testing failed to demonstrate any long term effect. Follow-up on firemen exposed at the same fire gave similar results. The initial interviews suggested that one worker had a chronic bronchitis aggravated by HF exposure at the fire.

Blood tests on current workers was normal except for the usual white cell increases associated with current or recent infections and slight abnormalities in size and/or shape of red cells. The red cell abnormalities do not appear to have any clinical significance, but do appear to relate to a history of exposure to lead, leaded gasoline, and/or solvents. They are also related to slightly higher FEP levels, although again no clinical significance can be attached to the findings. All lead levels were well within the normal range as would be expected among workers where lead exposures would be primarily to organic lead (TEL).

Review of medical records and telephone interviews suggested that exposure to fumes emanating from a manhole during a sewer cleanout were a significant factor in the one case of aplastic anemia in an ex-worker. Although the worker in the sewer wore adequate respiratory protection, this worker apparently did not.

Further study at this plant for an increased incidence of leukemia or other serious blood abnormalities does not seem warranted except as part of a more general study. The numbers are small, the current blood work normal, job overlap and progression are the rule, and other studies have already demonstrated the risk.

VIII. RECOMMENDATIONS

1. Evaluation of the laboratory ventilation system and installation of better exhaust fans and chemical laboratory hoods.

2. Enforcement of a respiratory program that fulfills all of the OSHA requirements under 29 CFR 1910.134.

3. Pay particular attention to the possible need for respiratory protection during non-routine procedures. If in doubt, err on the side of protection.

4. Periodic screening of welders for respiratory complaints would be desirable. Medical surveillance as described in the NIOSH Criteria for a Recommended Standard...Occupational Exposure to Refined Petroleum Solvents, HEW Publication No. (NIOSH) 77-192, would be appropriate. This calls for pre-employment and annual examinations and blood work as a minimum.

IX. REFERENCES

1. Knudson, R.M., Slatin, R.C., Lebowtiz, M.D., and Burrows, B., "The Maximal Expiratory Flow-Volume Curve: Normal Standards, Variability, and Effects of Age." Am. Rev. Resp. Dis. 113:587-600 (1976).

2. Plunkett, E.R., Handbook of Industrial Toxicology, Chemical Publishing Company, New York, 1976, pp. 5-6.

3. International Labour Office, Encyclopaedia of Occupational Health and Safety. McGraw-Hill Book Company, New York (1971), pp. 686-689, 1027-1031.

4. Dean, J.A., ed., Lang's Handbook of Chemistry, 12th Edition. McGraw-Hill Book Company, New York (1979), Table 7-4, Physicial Constants of Organic Compounds.

5. Plunkett, op. cit., pp. 50-52.

6. NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards, DHHS Publication No. (NIOSH) 81-123, Cincinnati, Ohio, 1978.

7. International Labour Office, op. cit., pp. 557-559.

8. Occupational Safety and Health Administration. Occupational exposure to lead--final standard. Federal Register 1978 Nov 14:53007.

9. International Labour Office, op. cit., pp. 765-767.

10. Criteria for a Recommended Standard...Occupational Exposure to Toluene, HEW Publication No. (NIOSH) 73-11023, Cincinnati, Ohio, 1973.

11. Criteria for a Recommended Standard...Occupational Exposure to Xylene, HEW Publication No. (NIOSH) 75-168, Cincinnati, Ohio, 1976.

12. Corre, F., Lellouch, J., and Schwartz, D., "Smoking and Leukocyte-Counts: Results of an Epidemiological Survey." Lancet, 2:632-634 (1971).

13. Thomas, T.L., Waxweiler, R.J., Moure-Eraso, R. and Fraumeni, J.F., Jr., "Mortality Patterns Among Workers in Three Texas Oil Refineries." J. Occ. Med. 24:135-141 (1982).

X. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared By:

Bobby J. Gunter, Ph.D.
Regional Industrial Hygienist
NIOSH, Region VIII
Denver, Colorado

Theodore W. Thoburn, M.D.
Medical Officer
NIOSH, Region VIII
Denver, Colorado

Evaluation Assistance:	George R. Schutte Chief, Medical Services Section Support Services Branch (SSB) Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS) NIOSH, Cincinnati, Ohio
	Kenneth R. Casey, M.D. Rocky Mountain Center for Occupational and Environmental Health University of Utah Salt Lake City, Utah
Originating Office:	Hazard Evaluation and Technical Assistance Branch (HETAB) Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS) NIOSH, Cincinnati, Ohio
Report Typed By:	Marilyn K. Schulenberg Occupational Health Technician NIOSH, Region VIII Denver, Colorado

XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. Phillips Petroleum Company.
2. Oil, Chemical and Atomic Workers International Union.
3. Oil, Chemical and Atomic Workers Local Union 2-578.
4. U.S. Department of Labor/OSHA - Region VIII.
5. NIOSH - Region VIII.
6. Utah State Department of Health.
7. State Designated Agency.

For the purpose of informing affected employees, a copy of this report shall be posted in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

Job Breakdown of Workers Included in Medical Aspects of Study

Phillips Petroleum Company Refinery
Woods Cross, Utah

Job Category	Interviews (in person & phone) Aug. 18-20, 1980 & following	Questionnaires & Blood Work Oct. 15-16,1980
Yardmen	3 *	11
Senior Pumpers (Tank Farm)	2	4
Gas Dock Loader	1	1
Laboratory Workers	6	9
Operators	9	14
Stillmen	4	2
Instrument Electricians	1	6
Pipefitters & Welders	4	6
Other Maintenance Workers	1	8
Boilerhouse Workers	2	0
Truck Driver	1	0
Engineers & Safety Workers	0	6
Night Supervisors	0	3
Office Workers	0	9
Totals	34	79

* Includes one ex-worker.

TABLE 2

Age, Years with Company, Years in Current Position*, Number of Women, and Number of Smokers by Job

Phillips Petroleum Company Refinery
Woods Cross, Utah

October 15-16, 1980

Job	Number	Age Mean±Std.Dev.	Years with Company Mean±Std.Dev.	Years in Position* Mean±Std.Dev.	Number of Women	Number of Current Smokers
Yardman	11	27.1 ± 3.2#	1.2 ± 0.9#	1.2 ± 0.9#	1	2
Tank Farm & Loading Dock	5	39.2 ± 16.2	9.1 ± 10.7	3.0 ± 1.7	1	2
Laboratory	9	35.1 ± 8.3	9.8 ± 7.7	3.0 ± 2.1	1	1
Operator & Stillman	16	36.6 ± 7.7	11.5 ± 5.5	4.2 ± 2.4	1	7
Instrument Electrician	6	33.0 ± 9.7	9.8 ± 10.3	6.4 ± 6.5	0	1
Pipefitter - Welder	6	49.5 ± 14.0@	26.0 ± 16.3@	12.8 ± 12.2@	0	2
Maintenance	8	45.1 ± 13.2	14.2 ± 11.6	7.6 ± 9.0	0	1
Engineer & Safety	6	38.2 ± 13.8	13.0 ± 14.3	11.8 ± 15.0	0	3
Night Supervisor	3	45.3 ± 16.5	23.0 ± 16.8	2.8 ± 2.3	0	2
Office	9	52.3 ± 10.6¢	18.6 ± 11.5	8.5 ± 7.3	5	3
Total	79	39.1 ± 12.6	12.3 ± 11.4	5.7 ± 7.4	9	24

* Current position if held at least 2 weeks, otherwise previous position.
# Statistically significant different from rest (t = -3.667, p = less than 0.01; t = -3.770, p = less than 0.01; t = -2.281, p = 0.028 respectively)(77 d.f)
@ Statistically significant different from rest (t = 2.160, p = 0.037; t = 3.224, p = less than 0.01; t = 2.507, p = 0.015 respectively)(77 d.f)
¢ Statistically significant different from rest (t = 3.608, p = less than 0.01)(77 d.f)

TABLE 3

Breathing Zone and General Room Air Concentrations of
Benzene, Toluene, and Xylene

Phillips Petroleum Refinery
Woods Cross, Utah

August 18-20, 1980

Sample Number	Job Classification	Location	Sampling Time	mg/M³ Benzene	Toluene	Xylene
1	Unit 4	Gas Plant Operator	7:46 AM - 3:03 PM	0.05	*	0.5
2	Laboratory	General Room (Asphalt)	8:26 AM - 3:07 PM	1.26	4.2	6.3
3	Laboratory	Laboratory Tester	10:11 AM - 3:07 PM	1.6	5.0	6.3
4	Units 4 & 5	Stillman	7:48 AM - 3:04 PM	*	*	*
5	Laboratory	Asphalt Tester	8:10 AM - 3:10 PM	1.5	5.2	4.8
6	Reformer	Operator All Units	7:32 AM - 2:55 PM	*	*	*
7	Laboratory	Knock Tester	8:30 AM - 3:15 PM	0.4	1.4	1.0
8	Units 8 & 10	Crude Operator	7:35 AM - 2:57 PM	*	*	*
9	Laboratory	Analytical (Fluoride)	8:15 AM - 3:10 PM	0.4	1.4	1.4
10	Laboratory	Asphalt Tester	8:08 AM - 4:02 PM	0.6	2.5	2.0
11	Laboratory	Laboratory Tester	8:10 AM - 2:45 PM	0.6	2.2	1.7
12	Laboratory	General Room	8:14 AM - 1:00 PM	2.0	6.2	4.8
13	Laboratory	Asphalt Tester	8:03 AM - 10:30 AM	*	*	*
14	Laboratory	Special Tester	8:05 AM - 4:00 PM	0.6	2.8	2.2
15	Gas Dock	Loader	7:46 AM - 3:03 PM	1.3	2.7	0.7
16	North Units	Operator (Gas Plant)	3:52 PM - 9:50 PM	*	*	*
17	Unit 6	Operator (Reformer)	3:40 PM - 10:00 PM	0.06	*	*
18	Laboratory	Shift Tester	3:55 PM - 9:50 PM	0.5	1.7	1.1
19	Laboratory	General Room	3:55 PM - 9:55 PM	0.3	1.1	0.8
20	Reformer	Operator	7:45 AM - 3:02 PM	8.8	37.0	38.0
21	Laboratory	General Room	8:10 AM - 3:10 PM	1.0	5.0	3.7
23	West Tank Farm	Senior Pumper	7:15 AM - 3:07 PM	0.1	*	*
24	Laboratory	Asphalt Tester	8:08 AM - 2:42 PM	0.95	3.8	2.9
25	Laboratory	Special Tester	8:05 AM - 3:02 PM	0.67	2.0	2.4
EVALUATION CRITERIA				3.2 C	750	435
LABORATORY LIMIT OF DETECTION mg/sample				0.001	0.01	0.01

* = below laboratory limit of detection
C = Ceiling concentration - 30 minute

TABLE 4

Breathing Zone Air Concentrations of Lead

Phillips Petroleum Refinery
Woods Cross, Utah

August 18-21, 1980

Sample Number	Job Classification	Location	Sampling Time	mg/M^3 Lead
AA5	Senior Pumper	West Tank Farm	7:37 AM - 2:59 PM	0.003
AA6	Knock Tester	Laboratory	8:14 AM - 1:00 PM	0.003
AA15	Knock Tester	Laboratory	9:00 AM - 4:00 PM	0.003
AA20	Loader	Loading Dock	7:26 AM - 3:00 PM	0.003
AA2471	Knock Tester	Laboratory	8:23 AM - 3:15 PM	0.003
EVALUATION CRITIERA				0.05
LABORATORY LIMIT OF DETECTION mg/filter				0.003

TABLE 5

Breathing Zone and General Room Air Concentrations of Hydrogen Fluoride (HF)

Phillips Petroleum Refinery
Woods Cross, Utah

August 21-22, 1980

Sample Number	Job Classification	Location	Sampling Time	mg/M^3 Hydrogen Fluoride
HF1	Operator	Units 7 - 11	7:30 AM - 1:01 PM	0.02
HF2	HF Tester	Laboratory	8:04 AM - 11:08 AM	0.11
HF10	General Area	Unit 7	8:36 AM - 2:55 PM	0.09
HF11	Pump Helper Mechanic	Unit 7	8:55 AM - 3:20 PM	0.01
HF12	Pump Mechanic	Unit 7	8:56 AM - 3:28 PM	0.70
HF13	Stillman	South Units	3:38 PM - 9:50 PM	0.07
HF14	Stillman	Unit 7	3:38 PM - 9:48 PM	0.14
HF20	General Area	Alkalylation Unit	7:55 AM - 3:10 PM	2.30
HF21	Stillman	Unit 6	7:50 AM - 3:10 PM	0.04
HF22	Pump Mechanic	Unit 7	8:10 AM - 2:42 PM	0.64
HF23	Pump Mechanic	Unit 7	8:10 AM - 2:42 PM	0.37
EVALUATION CRITIERA				2.5
LABORATORY LIMIT OF DETECTION mg/sample				0.003

TABLE 6

Breathing Zone and General Room Air Concentrations of
Benzene, Toluene, Xylene, and Acetone

Phillips Petroleum Refinery
Woods Cross, Utah

October 17, 1980

Sample Number	Job Classification	Location	Sampling Time	mg/M³ Benzene	Toluene	Xylene	Acetone
1	Operator	South Units	7:35 AM - 2:30 PM	*	*	*	*
2	Operator	Catalytic Cracker	7:30 AM - 2:40 PM	*	*	*	*
3	Stillman	South Units	7:30 AM - 2:40 PM	0.05	*	*	2.5
4	Tester	Laboratory	8:22 AM - 3:05 PM	0.7	1.7	1.7	78.0
5	Loader	Loading Dock	8:14 AM - 2:55 PM	2.8	7.2	5.0	7.0
6	Reformer Operator	South Units	7:28 AM - 2:40 PM	0.07	*	*	*
7	General Room	Laboratory Hood	8:25 AM - 3:05 PM	0.7	2.0	2.0	22.0
8	Asphalt Tester	Laboratory	8:22 AM - 3:05 PM	1.7	4.7	3.3	0.79
9	Tester	Laboratory	8:35 AM - 2:30 PM	1.7	5.0	38.0	47.0
10	General Room	Laboratory	8:20 AM - 3:05 PM	1.7	4.7	3.3	52.0
EVALUATION CRITERIA				3.2 C	750	435	1780
LABORATORY LIMIT OF DETECTION mg/sample				0.001	0.01	0.01	0.02

* = below laboratory limit of detection

C = Ceiling concentration - 30 minute

TABLE 7

Blood Work by Sex and Current Smoking Status

Phillips Petroleum Company Refinery
Woods Cross, Utah

October 15-16, 1980

Test		Normal (for laboratory doing test)	Men: Smokers Mean±Std.Dev.	Men: Non-Smokers Mean±Std.Dev.	Men: Total Mean±Std.Dev.	Women Mean±Std.Dev.
Number of Tests			(21)	(49)	(70)	(9)
White Blood Count (WBC) - Total		4.3-10.0x10³/ul	8.94±1.69*	7.01±1.51*	7.59±1.79	6.88±1.10
Neutrophils		1.8- 7.7x10³/ul	5.36±1.63**	4.01±1.42**	4.41±1.60	4.37±0.90
Lymphocytes		1.0- 4.8x10³/ul	3.01±0.71@	2.48±0.76@	2.64±0.78	2.20±0.36
Red Blood Count (RBC)	Male Female	4.4- 6.0x10⁶/ul 4.2- 5.4x10⁶/ul	5.30±0.29	5.27±0.27	5.28±0.28@@	4.79±0.34@@
Hemoglobin (Hgb)	Male Female	14-18 g/dl 12-16 g/dl	16.88±0.99	16.52±0.83	16.62±0.89#	14.80±0.81#
Hematocrit (Hct)	Male Female	42-52 % 37-47 %	48.09±2.55+	46.53±2.32+	47.00±2.48++	42.78±2.30++
Mean Corpuscular Volume (MCV)	Male Female	80-96 microns³ 79-97 microns³	91.1±4.3##	88.5±3.0##	89.3±3.6	89.3±2.7
Mean Corpuscular Hemoglobin (MCH)		27-34 pg	32.1±1.8	31.5±1.1	31.7±1.4	31.2±1.2
Mean Corpuscular Hemoglobin Concentration (MCHC)		32-36 %	35.1±0.5¢	35.5±0.6¢	35.4±0.6¢¢	34.6±0.7¢¢
Number of Tests			(5)	(12)	(17)	(2)
Free Erythrocyte Protoporphyrin (FEP)		16-50 ug/dl	21.8±5.0	31.4±13.3	28.6±12.1	24.0
Blood Lead		less than 40ug/dl	9.4±3.8	9.0±2.0	9.1±2.5	7.0

TABLE 7 (continued)

Blood Work by Sex and Current Smoking Status (Footnotes)

Phillips Petroleum Company Refinery
Woods Cross, Utah

* Statistically significant difference (t = 4.731, p = less than 0.01) (68 d.f.)

** Statistically significant difference (t = 3.496, p = less than 0.01) (68 d.f.)

@ Statistically significant difference (t = 2.693, p = less than 0.01) (68 d.f.)

@@ Statistically significant difference (t = 4.897, p = less than 0.01) (77 d.f.)

Statistically significant difference (t = 5.835, p = less than 0.01) (77 d.f.)

\+ Statistically significant difference (t = 2.511, p = 0.015)(68 d.f.)

++ Statistically significant difference (t = 4.838, p = less than 0.01) (77 d.f.)

Statistically significant difference (t = 2.863, p = less than 0.01) (68 d.f.)

¢ Statistically significant difference (t = 2.894, p = less than 0.01) (68 d.f.)

¢¢ Statistically significant difference (t = 3.800, p = less than 0.01) (77 d.f.)

TABLE 8

Possible Factors Relating to Abnormal Red Blood Cells (RBCs)

Phillips Petroleum Company Refinery
Woods Cross, Utah

October 15-16, 1980

Factor	Total Number	Number with Abnormal RBCs
Solvent Exposures:		
Gas Dock	2	2
Night Supervisors (Gas Dock)	3	3
Other on-the-job solvent exposures	2	1
Off-job exposures (working on cars, models, furniture)	5	4
Totals	12*	10*
Lead Exposures:		
Tetraethyl Lead (TEL) (Gas Dock, unloading rail cars, Night Supervisors, Anti-knock Tester)	7	6
Off-job gasoline exposure	3	3
Off-job ammunition loading or indoor firing	2	2
Totals	12*	11*
Medications:	2	2
Total with one or more factors identified	18*	16*
Total with no factors identified	61	5
Totals	79	21

* Probability by Fisher's Exact Test less than 0.001.

TABLE 9

White Blood Count (WBC), Neutrophils and Free Erythrocyte Protoporphyrin (FEP) by Presence of Abnormal Red Blood Cells (RBCs) and History of Exposure to Tetraethyl Lead (TEL) Gasoline, Other Lead, and/or Regular Medication (Males only)

Phillips Petroleum Company Refinery
Woods Cross, Utah

October 15-16, 1980

Normals	Number	WBC Mean±Std.Dev. 4.3-10.0 $x10^3$/ul	Neutrophils Mean±Std.Dev. 1.8- 7.7 $x10^3$/ul	Number	FEP Mean±Std.Dev. 16-50 ug/dl
Total Group	70	7.59±1.79	4.41±1.60	17	28.6±12.1
Abnormal RBCs present	21	7.02±1.38	3.89±1.32	7	36.7±14.1*
History of Exposure to TEL, gasoline, other lead, and/or current medications	14	6.60±1.35**	3.35±0.89+	7	36.7±14.1*
History of Exposure to TEL, gasoline, or other lead	12	6.63±1.45++	3.25±0.77@	6	32.3±8.7@@
No History of Exposure to TEL, gasoline, other lead and/or current medication	56	7.84±1.81++	4.68±1.63@	10	22.9±6.5@@
Current Smokers - Total	21	8.94±1.69	5.36±1.63	5	21.8±5.0
Abnormal RBCs Present	6	7.90±1.40	4.86±1.63	2	26.0±1.41
History of Exposure to TEL and/or gasoline	3	7.20±1.21	3.69±0.63	2	26.0±1.41
Non-Smokers and Ex-Smokers - Total	49	7.01±1.51	4.01±1.42	12	31.4±13.1
Abnormal RBCs Present	15	6.67±1.25	3.51±0.98	5	41.0±14.7#
History of Exposure to TEL, gasoline, and/or current medication	11	6.44±1.39	3.26±0.96##	5	41.0±14.7#
History of Exposure to TEL or gasoline	9	6.44±1.53	3.11±0.79¢	4	35.5± 9.3
No History of Exposure to TEL, gasoline, and/or current medication	38	7.18±1.52	4.22±1.47¢	7	24.6±6.9

TABLE 9 (continued)

White Blood Count (WBC), Neutrophils and Free Erythrocyte Protoporphyrin (FEP) by Presence of Abnormal Red Blood Cells (RBCs) and History of Exposure to Tetraethyl Lead (TEL) and/or Gasoline, and/or Regular Medication (Males only)
(Footnotes)

Phillips Petroleum Company Refinery
Woods Cross, Utah

* Statistically significantly different from rest of Total Group
(t = 2.738, p = 0.016)(15 d.f.)

** Statistically significantly different from rest of Total Group
(t = 2.401, p = 0.019)(68 d.f.)

\+ Statistically significantly different from rest of Total Group
(t = 2.916, p = less than 0.01)(68 d.f.)

++ Statistically significantly different from each other
(t = 2.165, p = 0.037)(66 d.f.)

@ Statistically significantly different from each other
(t = 2.935, p = less than 0.01)(66 d.f.)

@@ Statistically significantly different from each other
(t = 2.469, p = 0.030)(14 d.f.)

\# Statistically significantly different from rest of Non- & Ex-Smokers
(t = 2.621, p = 0.028)(10 d.f.)

\## Statistically significantly different from rest of Non- & Ex-Smokers
(t = 2.042, p = 0.048)(47 d.f.)

¢ Statistically significantly different from each other
(t = 2.189, p = 0.037)(45 d.f.)

TABLE 10

Pulmonary Function Results for Firemen and Symptomatic Workers
Exposed to Hydrogen Fluoride (HF) at the Fire of May 2, 1980

Phillips Petroleum Company Refinery
Woods Cross, Utah

Group & Date	Number	Forced Vital Capacity (FVC) % Predicted Mean±Std.Dev.	# below 80%	Forced Expiratory Volume, 1 second (FEV_1) % Predicted Mean±Std.Dev.	# below 80%	FEV_1/FVC % Mean±Std.Dev.	# below 70%
Firemen 5-7-80	14	100.5±15.4	2	100.9±16.9	2	82.4±4.5	0
Firemen 8-19-81	8	98.4±10.6	1	95.6±10.5	1	79.8±5.2	0
Firemen Change in % of Predicted (8-19-81) - (5-7-80)	8	+0.6± 3.6	--	-1.8± 8.2	--	-2.3± 5.4	--
Symptomatic Workers Fall, 1981	9	107.0±13.4	0	106.7±13.5	0	80.3±3.2	0

TABLE 11

Activity at Fire, Hydrogen Fluoride (HF) Exposure, and Presence of Symptoms as Reported on Questionnaire, October 15-16, 1980

Phillips Petroleum Company Refinery
Woods Cross, Utah

Activity, HF Exposure & Presence of Symptoms	Number	Number with Pulmonary Function Tests	Time on Hoses (hours) Mean	Std.Dev.
Manning Hoses	42	6	2.78*	±1.36
No Symptoms	33	0	2.77*	±1.34
Symptoms	9	6	2.81*	±1.55
No HF Exposure — No Symptoms	16	0	2.53	±1.30
Normal or less than normal HF Exposure	17	3	2.86*	±1.50
No Symptoms	13	0	2.83	±1.59
Symptoms	4	3	3.00*	±1.32
Greater than normal HF Exposure	9	3	3.12*	±1.38
No Symptoms	4	0	3.83*	±0.29
Symptoms	5	3	2.70	±1.82
Not Manning Hoses	16	3	--	--
No Symptoms	12	0	--	--
Symptoms	4	3	--	--
No HF Exposure — No Symptoms	11	0	--	--
Normal or less than normal HF Exposure	3	2	--	--
No Symptoms	1	0	--	--
Symptoms	2	2	--	--
Greater than normal HF Exposure — Symptoms	2	1	--	--

* Two men on hoses for an indeterminant time omitted - one with symptoms, one without.

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ROBERT A. TAFT LABORATORIES
4676 COLUMBIA PARKWAY, CINCINNATI, OHIO 45226

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE. $300

Third Class Mail

U.S.MAIL

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF HHS
HHS 396